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INTRODUCTION.

This REVIEW treats generally the meteorological conditions of the United States and Canada for May, 1889, and is based upon reports of regular and voluntary observers of both countries.

On chart i the paths of the centres of eight areas of low pressure are shown; the average number traced for May during the last fifteen years being 8.8. This chart also exhibits the paths of the centres of nine depressions traced over the north Atlantic Ocean; the limits of fog-belts west of the fortieth meridian, and the distribution of icebergs and field ice during the month. The areas of high and low pressure and north Atlantic storms are discussed under their respective headings.

Chart ii exhibits the distribution of mean atmospheric pressure and temperature and the southern and western limits of freezing weather for the month. The mean temperature was below the normal over a greater portion of the interior and southern parts of the country, the departures below the normal being small. In other districts the month was generally warmer than the average May, the greatest departures above the normal being shown in the Canadian Maritime Provinces, where they exceeded 6°. At a number of stations east of the Mississippi River, in Texas, and Washington Territory, the maximum temperature exceeded the highest May temperature recorded during the periods of observation, while at several stations in the Southern States, and from Texas northward to the British Possessions the lowest temperature recorded for May during the periods of observation was noted.

Chart iii shows the distribution of precipitation for May, 1889. The precipitation was generally in excess of the normal over the northern half of the country from the Atlantic to the Pacific. The most marked excesses in precipitation occurred on the middle Pacific coast, where the rainfall was about 250 per cent. above the normal amount for May, and in the middle Atlantic states, where it was about 50 per cent. in excess of the May average. The greatest deficiencies occurred in the southern plateau region, where but about 6 per cent. of the usual amount of rain for the month fell, and in the Rio Grande Valley, where the rainfall equalled about 20 per cent. of the May average. Marked deficiencies also occurred in the Gulf states and Florida. The exceptionally heavy rains and resultant floods of the last two days of the month in sections of the middle states form the subject of extra charts and tables and are specially discussed in this issue of the REVIEW. A deficiency of rainfall caused serious droughts in sections of the Southern States.

In the preparation of this REVIEW data from 2,535 stations have been used, classified as follows: 176 Signal Service stations; 122 monthly registers from United States Army post surgeons; 1,712 monthly registers from state weather service and voluntary observers; 24 Canadian stations; 169 stations through the Central Pacific Railway Company; 332 marine reports through the co-operation of the Hydrographic Office, United States Navy; marine reports through the "New York Herald Weather Service;" monthly weather reports from the local weather services of Alabama, Arkansas, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Nebraska, Nevada, New England, New Jersey, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, and Texas, and international simultaneous observations. Trustworthy newspaper extracts and special reports have also been used.

ATMOSPHERIC PRESSURE (expressed in inches and hundredths).

The distribution of mean atmospheric pressure for May, 1889, as determined from observations taken daily at 8 a. m. and 8 p. m. (75th meridian time), is shown on chart ii by isobars. The difference between the mean pressure for May obtained from observations taken twice daily at the hours named and that determined from hourly observations varies at the stations named below, as follows: At Washington, D. C., Philadelphia, Pa., New York, N. Y., Boston, Mass., Saint Louis, Mo., and Chicago, Ill., the mean of the 8 a. m. and 8 p. m. observations was higher by .009, .008, about .009, .006, .002, and .001, respectively, while at San Francisco, Cal., the mean of the observations taken at these hours was about .016 lower than the true mean pressure.

The mean pressure for May, 1889, was highest along the east Gulf coast and over Florida, where it rose above 30.05, the highest mean reading, 30.07, being reported at Mobile, Ala. Over South Carolina, Georgia, Tennessee, the east Gulf states, Arkansas, Louisiana, eastern and southeastern Texas, and the northern California coast the mean pressure was above 30.00. The mean pressure was lowest over southern Nevada and the adjoining part of California, where it fell below 29.80, the lowest reading, 29.78, being reported at Keeler, Cal. A trough of low mean pressure, within which the values varied from 29.80 to 29.90, extended from the lower Colorado valley northward over the plateau and Rocky Mountain regions to the Saskatchewan Valley. The mean pressure was below 29.90 in the lower Saint Lawrence valley.

Compared with the pressure chart for April, 1889, an increase in pressure is shown over the Gulf and south Atlantic states, Florida, at stations on the middle Atlantic and southern New England coasts, and over southern Nova Scotia; elsewhere over the country there has been a decrease in pressure. The greatest increase in pressure was noted on the North Carolina coast, where it amounted to .05, and the greatest decrease, about .10, in the British Possessions north of Dakota, and in the lower Missouri valley. In April the mean pressure was highest along the Pacific coast north of the thirty-fifth parallel, while for the current month the highest values were reported on the middle coast of the Gulf of Mexico. The area of lowest mean pressure for the current and the preceding

month occupied the southern plateau region, where the decrease varies from .04 to .07.

Compared with the normal pressure for May the mean pressure was above the normal over the southern plateau region, and from Dakota and eastern Montana southward and southeastward to the Gulf states and Florida; elsewhere the mean pressure was below the normal. The greatest departures above the normal were reported along the middle and west Gulf coast, where they exceeded .05. The most marked departures below the normal were noted on the north Pacific coast and in the valley of the Columbia River, on the Atlantic coast between the thirty-sixth and thirty-ninth parallels, and at stations in the Saint Lawrence Valley, where they were more than .05.

BAROMETRIC RANGES.

The monthly barometric ranges at the several Signal Service stations are given in the table of miscellaneous meteorological data. The general rule, to which the monthly barometric ranges over the United States are found to conform, is that they increase with the latitude and decrease slightly, though somewhat irregularly, with increasing longitude. In May, 1889, the ranges were greatest in Dakota, where they exceeded 1.40, whence they decreased eastward to Lakes Huron and Erie, where they were less than .60, and thence increased to the coast of Maine, where they were more than .80. The ranges decreased southward to southern Florida, where they were .30, and to the south coast of California, where they were less than .20. From Dakota westward the ranges decreased to about .80 in the upper valley of the Columbia River, and thence increased to more than 1.00 on the coast of Washington. Along the Atlantic coast the extreme ranges varied from .30 at Key West, Fla., to .89 at Eastport, Me.; between the eighty-second and ninety-second meridians, .49 at Cedar Keys, Fla., to .76 at La Crosse, Wis.; between the Mississippi River and the Rocky Mountains, .44 at Galveston, Tex., to 1.48 at Huron and Saint Vincent, Dak.; in the plateau and Rocky Mountain regions, .31 at Yuma, Ariz., to 1.00 at Fort McKinney, Wyo.; on the Pacific coast, .19 at San Diego, Cal., to 1.03 at Fort Canby, Wash.

AREAS OF HIGH PRESSURE.

Seven areas of high pressure were observed in or near the limits of the United States during the month of May, three of which were first observed on the Pacific coast, and three approached the stations from the region north of Dakota. These areas moved generally in a southeasterly direction east of the Rocky Mountains, while the movement was to the north of east on the Pacific coast. Four of the areas observed passed over the Atlantic, two disappearing off the south Atlantic coast, while two passed over the north Atlantic. Two of the areas of high pressure which originated on the Pacific coast disappeared by gradual decrease of pressure while central over the Rocky Mountain region.

The following table exhibits in a concise manner some of the more prominent characteristics of the high areas:

No.	First observed.			Last observed.		Duration.	Velocity per hr.	Highest pressure.		
	Date.	Lat. N.	Long. W.	Lat. N.	Long. W.			Date.	Station.	Reading.
		°	°	°	°	*Days.*	*Miles.*			*Inches.*
I.....	1	54	103	32	84	5.0	19	1	Qu'Appelle, N.W.T....	30.58
II.....	8	44	129	37	102	5.0	16	9	Roseburgh, Oregon.....	30.38
III.....	13	53	98	42	57	7.0	21	17	Chatham, N.B.....	30.48
IV.....	15	40	128	30	80	8.5	20	20	Cheyenne, Wyo.....	30.42
V.....	21	43	127	40	99	4.0	25	21	Fort Canby, Wash.....	30.30
VI.....	28	55	97	47	92	3.0	10	30	Duluth, Minn.....	30.38
VII.....	29	42	77	43	57	2.5	16	30	Halifax, N.S.....	30.42
Mean.	.....	.....	.....	.....	.....	5.0	18.1	.....	.....	30.42

The following is a general description of each area, giving its movement and the more prominent weather conditions observed during its transit over the regions of observations:

I.—On the morning of the 1st this area was central far to the north of Dakota, but it had already extended southward over the eastern slope of the Rocky Mountains to Texas, light frosts having occurred throughout the Northwest and the lake region, the temperature being below freezing in northern Dakota. This area moved directly southward, it being attended by clear weather over the central valleys during the 2d and 3d, causing killing frosts in Nebraska on the 2d and light frosts in the central valleys on the 3d and 4th. After reaching the Indian Territory it passed directly eastward, extending over the entire country east of the Mississippi, causing light frosts in the northern portions of the Gulf states, Tennessee, and North Carolina, and killing frosts in western Virginia, on the 4th. It covered the Atlantic and Gulf states during the 5th and 6th, and finally disappeared after reaching the south Atlantic coast.

II.—This area was central to the west of Oregon on the morning of the 8th, after which it moved slowly to the northeast, approaching the coast, where it remained until the morning of the 10th, a secondary high area forming over the northern Rocky Mountain region during the 9th, after which the pressure decreased on the north Pacific coast, and the secondary area becoming more extended, covering the northern and central Rocky Mountain regions on the 11th, attended by heavy snows and freezing weather in Colorado and Wyoming. It moved directly southward during the 12th, attended by a general decrease of pressure, and disappeared while central over northern Texas on the 13th.

III.—This area of high pressure, although well defined while passing over the northeastern portions of the United States, was at no time central within the limits of the stations of observation. It was observed north of Dakota on the 13th, and passed eastward, reaching the lower Saint Lawrence valley on the 16th, where its course apparently changed to the southward. After extending over the Maritime Provinces, it apparently passed to the southward of Nova Scotia, and was central off the middle Atlantic coast on the 18th, from which region it moved to the northeastward, it being last observed as central to the southeast of Nova Scotia on the 20th.

IV.—This area approached the stations from the Pacific, it being first observed to the west of California on the 15th, where it remained almost stationary during the succeeding forty-eight hours, after which it moved northward, it being central near the mouth of the Columbia River on the afternoon of the 18th. From this position it passed directly southeastward, crossing the Rocky Mountains and extending over the eastern slope on the 21st, forming a ridge of high pressure from Texas northward to Manitoba with two centres, one in Indian Territory and one in Minnesota. The area continued to move eastward after the 21st, the southern area disappearing to the southward over the Gulf, while the northern area moved to the southeastward over the lake region and the central valleys, disappearing off the south Atlantic coast on the 24th. Light frosts occurred in North Carolina, Tennessee, and the Ohio valley on the 23d.

V.—This area also approached the stations from the Pacific. A trough of low pressure extended from Arizona northward over the plateau regions; the preceding area of high pressure covered the eastern Rocky Mountain slope, while area number v extended along the Pacific coast. The area of low barometer which developed within the barometric trough moved to the northeast over British America, and was followed by this area of high pressure which reached the north Pacific coast on the 22d, after which the direction of movement apparently changed to the eastward, the line of greatest pressure being parallel with, and near to, the northern boundary of the United States until the centre reached the one-hundredth meridian. At this point the direction of movement changed to the south, and owing to a decrease of pressure within this area it became less clearly defined, and its movement as a separate area could not be traced after the morning of the 25th, when it extended over the lower Missouri valley.

VI and VII.—Number vi was observed far to the north of Minnesota on the 28th. It moved southward to Lake Superior during the 28th and 29th, where it remained almost stationary until the close of the month, the barometer being above the normal to the eastward, and a secondary area of high pressure (number vii) apparently forming over the lower lake region and the middle Atlantic states. The last-named area of high pressure moved to the northeastward, the pressure increasing during the easterly movement, thereby causing an increased barometric gradient in its west quadrants. The retarded movement of this area, after reaching the coast, was attended by continued southeasterly winds on the middle and south Atlantic coast.

AREAS OF LOW PRESSURE.

Eight areas of low pressure were observed during the month of May, two of which were traced from the north Pacific coast to the east of the Rocky Mountains, four developed in the Rocky Mountain regions, one in the upper Mississippi valley, and one in the upper Ohio valley. The general direction of movement east of the Rocky Mountains was to the northeast, four passing over the Saint Lawrence Valley; two disappeared to the north of the lake region, and one passed off the middle Atlantic coast and thence northeastward to Nova Scotia. The region of greatest frequency of areas of low pressure includes the central and eastern slope of the Rocky Mountains, and, with one exception, all areas of low pressure that passed over the Mississippi Valley reached their lowest latitude near the one-hundredth meridian. The following table exhibits the principal facts regarding these low areas:

No.	First observed.			Last observed.		Duration.	Velocity per hr.	Lowest pressure.		
	Date.	Lat. N.	Long. W.	Lat. N.	Long. W.			Date.	Station.	Reading.
		°	°	°	°	*Days.*	*Miles.*			*Inches.*
I	1	45	116	53	96	7.0	8.0	7	Fort Sully, Dak	28.96
II	8	37	103	50	64	6.5	18.0	15	Anticosti, Gulf of St. L.	29.60
III	13	47	123	38	98	1.5	24.0	14	Pueblo, Colo	29.38
IV*a*	15	41	112	51	87	2.5	30.0	15	Pueblo, Colo	29.52
IV*b*				49	69	7.0	18.0	16	Fort Elliott, Tex	29.42
V	22	41	81	47	60	2.5	21.0	24	Sydney, C. B. I	29.50
VI	20	53	118	51	79	2.5	26.0	21	Swift Current, N. W. T.	29.56
VII	26	43	93	52	68	2.5	25.0	27	Saugeen, Ont	29.42
VIII	28	37	102	48	80	3.5	21.0	28	Fort Elliott, Tex	29.56
Means						3.9	21.2			29.44

The following is a general description of the weather conditions attending each low area as determined from the regular telegraphic reports:

I.—This area was central over Oregon on the afternoon of the 1st, the trough of low pressure extending southward to Arizona, while the eastern slope of the Rocky Mountains and the central valleys were covered by an extended area of high pressure. The morning report of the 2d exhibited a slight southeast movement of this low area over the northern plateau region, but the succeeding reports show that the direction of movement changed to northeast, and that it continued this course until the 5th, when the centre was far to the north of Dakota, after which either the principal or secondary disturbance moved southward over the upper Missouri valley, increasing greatly in energy, causing unusually high winds in the northwestern states, which in many localities proved injurious to crops, and in some cases necessitated a replanting. This disturbance remained almost stationary over Dakota during forty-eight hours, the centre reaching its most southerly point at Fort Sully on the morning of the 7th, when the unusually low pressure of 28.96 was observed. This storm moved almost directly north from central Dakota and passed beyond the limits of observation during the night of the 8th without causing any marked disturbance in the regions east of the Mississippi, except the brisk and high winds which were reported in the upper lake region.

II.—This was a feeble disturbance which developed over the central Rocky Mountain region, and passed slowly southeastward to Texas between the 8th and 11th, attended by heavy local rains in Kansas, Missouri, and Indian Territory. After reaching northern Texas the direction of movement changed to northeast, and it passed over the central Mississippi and the Ohio valleys more as an area of local rains than as a well-marked cyclonic disturbance. The rain area extended during the easterly movement, and the pressure decreased at the centre of disturbance, causing the storm to be well defined as it passed over the Saint Lawrence Valley, and it disappeared northeast of New England on the 15th, the lowest observed pressure attending the storm being 29.60 at Anticosti, Gulf of Saint Lawrence.

III and IV.—An area of low pressure appeared on the north Pacific coast on the 11th, and after advancing to the northeastward during the 11th and 12th, covering the region north of Washington Territory, it passed southward over the northern and central plateau regions, attended by general rains on the Pacific coast as far south as San Francisco. The movement changed to the southeast and it passed over the central Rocky Mountain region during the 14th, dividing into two areas of low pressure, one covering Utah and the other extending over the central and eastern slope of the Rocky Mountains on the morning of the 15th. These areas of low pressure united during the 15th, central over Colorado, and were afterwards traced on the chart as area of low pressure number iv, and referred to in the table as numbers iv *a* and iv *b*. The p. m. report of the 15th exhibits a well-defined depression central in Colorado, the pressure at Pueblo being 29.38. The isobars bounding this disturbance were elliptical in general form, the longer axis being in the direction of movement. The weather was generally warm and fair in the southern quadrants, without rain, while colder northeasterly winds and rain prevailed from the Rocky Mountains eastward to the lake region, with occasional snows and freezing weather in the northwest quadrant. The disturbance divided during the night of the 15th, forming two areas—one central in northern Texas and the other in the Missouri Valley. The more northerly disturbance moved rapidly over Lake Superior, disappearing during the night of the 17th, while the depression to the southward remained almost stationary over northern Texas and Indian Territory during the 16th and 17th, after which it passed rapidly to the northeastward, and it was central in the upper Mississippi valley during the night of the 17th, attended by heavy rains in Missouri, Iowa, and southern Wisconsin. Very heavy rains also occurred in Texas and Arkansas, when the winds shifted to northerly after the passage of this storm. After moving northward to southern Minnesota the course of this storm was to the northeastward, passing over Lake Superior on the 18th, after which its course was uncertain, but it has been approximately traced eastward to the Saint Lawrence Valley, it being last located as central near Father Point on the morning of the 22d.

V.—This is a secondary disturbance which developed over Pennsylvania when the storm previously described was passing over the lower Saint Lawrence valley. It moved eastward to the middle Atlantic coast, causing dangerous winds from Hatteras north to Boston on the 23d. These gales were of brief duration, but the wind attained a velocity of fifty-two miles an hour on the North Carolina coast, forty miles on the New Jersey coast, and forty-six miles on the southern New England coast. The depression passed northeastward over Nova Scotia on the 24th with an apparent loss of energy.

VI.—This disturbance was at no time central within the limits of the United States, but it was observed northwest of Montana on the 20th. The succeeding reports show that it passed eastward north of, and nearly parallel to, the northern boundary of the United States. During its easterly movement it was apparently drawn to the southward as it approached the Lake region, where light rains fell during its transit. This storm probably united with number v over, or northeast of, the Maritime Provinces on the 25th.

VII.—This was a secondary disturbance which developed in the southern portion of a more extended low area central north of Minnesota on the 26th. It was first central in Iowa and moved eastward over the lake region, attended by general rains north of the Gulf states. It increased in energy during the easterly movement until it reached the upper Saint Lawrence valley. The minimum pressure, 29.42, occurred at Saugeen on the 27th, when the storm was central near that station. Dangerous westerly winds occurred in the Lake region and heavy rains with southerly gales on the New England and middle Atlantic coasts during the passage of this disturbance. The latter conditions were probably due more to a secondary depression which developed in the south Atlantic states during the 26th.

VIII.—This storm was first observed as central over eastern Colorado and northern Texas on the 28th. An elliptical area of low pressure extended from the Rio Grande northeastward to the lower Missouri valley on the 28th, with an area of high pressure to the northward which apparently forced this disturbance to the eastward over the lower Mississippi valley. On the 29th it covered the greater portion of the Southern States and Ohio Valley, attended by heavy rains from the Lake region southward, which continued during the northeasterly movement. After reaching the upper Ohio valley the disturbance separated, one centre of low pressure passing towards the coast over Virginia, while the other moved northward over the lower lakes. At the close of the month the southern disturbance was central in southern Virginia, attended by unusually heavy rains in the middle Atlantic states, and these rains continued during the succeeding day and caused destructive floods which form the subject of a special report in this REVIEW. On the back of chart i will be found supplementary charts giving the weather conditions attending the heavy rainfalls during the last days of May and the first of June over the region of destructive floods. It will be observed that the northern centre of disturbance, after reaching the Lake region, apparently divided, and at the close of the month two secondary depressions were indicated by the circulation of winds, one north of Lake Erie and one over southern Michigan. The development of the latter was especially favorable to the agricultural interests of the Northwest, as it caused a continuation of cloudiness, thereby preventing a destructive frost which must have occurred if clearing weather had prevailed on the morning of the 1st in the states north of the Ohio.

NORTH ATLANTIC STORMS FOR MAY, 1889 (pressure in inches and millimetres; wind-force by Beaufort scale).

The paths of the depressions that appeared over the north Atlantic Ocean during May, 1889, are shown on chart i. These paths have been determined from international simultaneous observations by captains of ocean steamships and sailing vessels received through the co-operation of the Hydrographic Office, Navy Department, and the "New York Herald Weather Service."

Nine depressions have been traced for May, 1889, the average number traced for the corresponding month of the last four years being ten. Generally fair weather prevailed and storms of unusual strength were not reported save on one date, the 21st, when gales of hurricane force were encountered off the middle Atlantic coast of the United States. Over the western part of the ocean a noteworthy feature was the advance northward from near the West Indies of two depressions. The remaining depressions passed eastward from the American continent, or first appeared over the ocean north of the fortieth parallel. Over mid-ocean strong gales were reported at intervals during the month. In the vicinity of the British Isles severe storms were not noted, although the barometric fluctuations were frequent and marked.

As compared with the corresponding month of previous years the depressions traced for May, 1889, were deficient in number and energy; they pursued normal tracks, and extreme low barometer readings noted in preceding years were not reported attending their passage. The following are brief descriptions of the depressions traced:

1.—This depression was a continuation of number 7 traced for April, 1889, and was central south of Ireland at noon, Greenwich mean time, of May 1st, with pressure falling to about 29.40 (747), and moderate to fresh gales to the twenty-fifth meridian. By the 2d the storm-centre had moved northwest over the British Isles, without evidence of marked strength.

2.—This depression was a continuation of low area xii for April, and on the 1st was central near the northeast coast of Newfoundland, with pressure below 29.60 (752) and fresh gales to the thirty-fifth parallel. Moving east to about longitude W. 39° by the 2d the depression is thence traced northeast to south of Iceland, where it disappeared after the 4th, attended throughout by fresh gales, and a gradual decrease in pressure.

3.—This depression was central over Newfoundland on the morning of the 4th, with pressure falling to about 29.60 (752), and fresh gales over and near the Grand Banks. By the 6th the storm-centre had moved east-northeast over mid-ocean north of the trans-Atlantic steamship routes, attended by fresh to strong gales, whence it passed east-southeast and disappeared south of the British Isles during the 9th with an apparent decrease in energy after the 6th.

4.—The presence of this depression, about midway between Bermuda and the Bahamas, was indicated by reports of the 5th, to which region it had apparently advanced from the southward. On this date fresh northerly gales were reported north and northeast of the Bahamas. During the next four days the centre of depression moved slowly east of north to the thirty-seventh parrallel, attended in the west quadrants by gales of moderate strength. The observer at Bermuda reports that on the 7th thunder-storms were observed all around the horizon from 3 a. m. until morning, and that very light showers prevailed on the island. After the 9th the depression apparently moved north-northeast to east of Nova Scotia, where it was central on the 10th, with pressure below 29.50 (749). From this position the storm-centre passed northeastward over Newfoundland, and thence eastward over the ocean, and disappeared south of the British Isles by the 14th, its passage being attended by a gradual decrease in energy.

5.—This depression appeared northeast of Newfoundland on the 8th and moved eastward to the thirtieth meridian by the 9th, attended by fresh to strong gales, and pressure below 29.40 (747). On the 10th the storm-centre was located west of Ireland, after which it moved eastward and disappeared over the British Isles with an apparent loss of energy.

6.—This depression is given an approximate path north of the West Indies from the 16th to 19th, during which period it possessed moderate energy. On the 19th the storm-centre was central in about N. 30°, W. 75′, whence it recurved northward, and on the morning of the 21st was located in about N. 36°, W. 72′. During this date the depression apparently moved northward and united with an area of low pressure which occupied the Saint Lawrence valley. Reports indicate that the disturbances attending this depression were not severe in their character, save on the 21st, when gales of hurricane force were reported. The lowest barometric pressure, about 29.60 (752), was also noted on the 21st.

7.—This depression was a continuation of low area ii which advanced rapidly eastward over northern Newfoundland during the 15th. On the 16th and 17th the depression moved slowly north of east over mid-ocean north of the fiftieth parallel, attended by fresh to strong gales, after which it disappeared north of the region of observation.

8.—This depression was a continuation of low area v, and